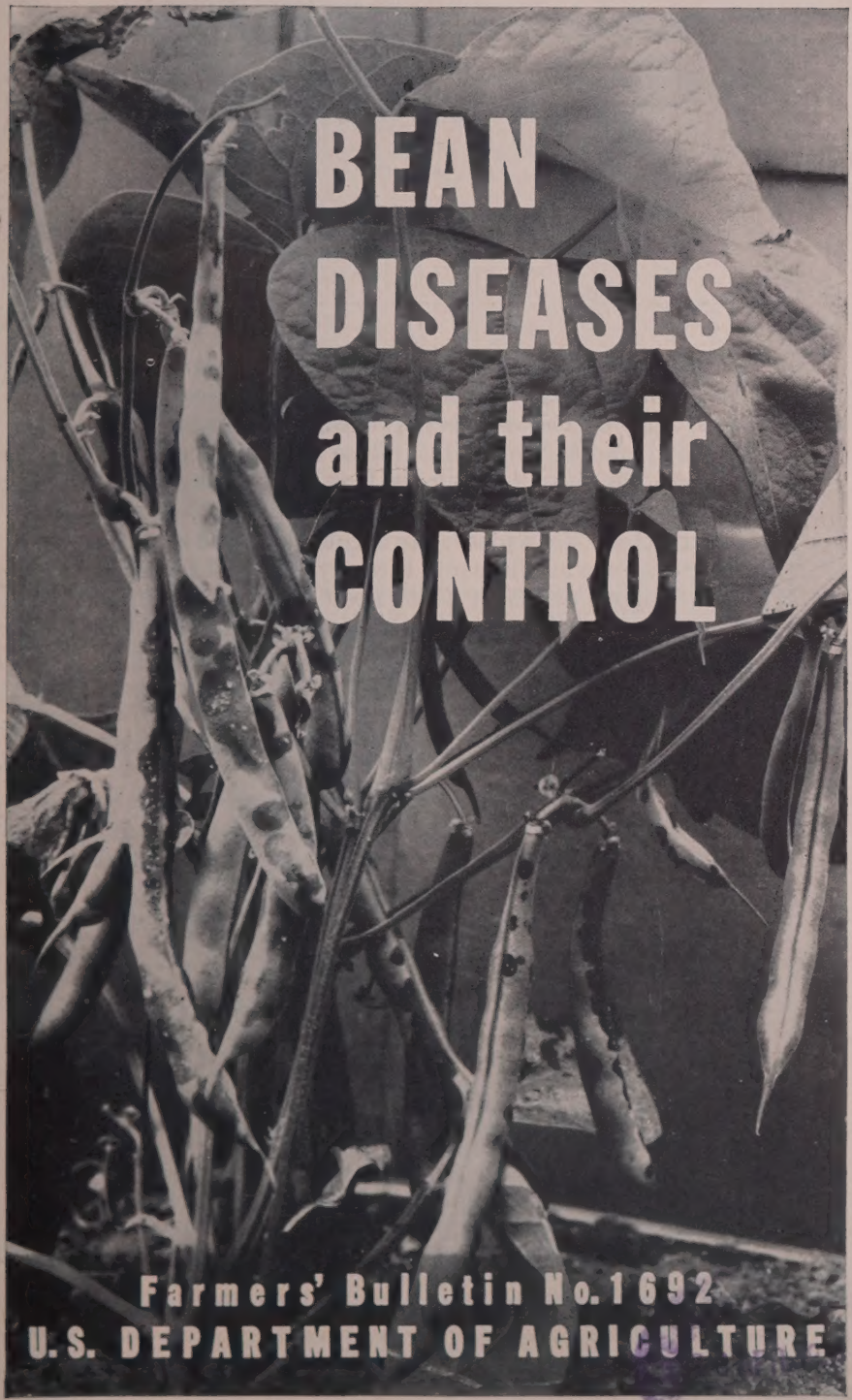
BEAN
DISEASES
and their
CONTROL
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OFTEN a bean grower plants crop failure right along with his seed beans. Infection with some of the most serious bean diseases is carried in the seed from infected plants, even when these seed look entirely sound. The first rule of success in growing beans, therefore, is to use seed known to come from plants that were not infected. Bean plants can become diseased because fungus spores are blown to them by the wind from infected living plants or from dead plant material or because spores, bacteria, or viruses are carried to them by insects, by water, or on the hands and clothing of farm workers. Root rot fungi are very likely to attack bean plants, particularly where beans have been grown without rotation and the plants are not strong and vigorous.

This bulletin tells the farmer and the gardener how to guard against infection of bean crops, how to identify each of the principal bean diseases, and how to deal with individual diseases if they appear. With reference to certain diseases, it names recommended bean varieties that have proved to be immune.

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BEAN DISEASES AND THEIR CONTROL

By W. J. ZAUMEYER, *senior pathologist*, and H. REX THOMAS,[1] *pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

Contents

	Page
Control practices	3
Using resistant varieties	3
Using disease-free seed	3
Crop rotation	3
Field sanitation	4
Seed treatment	4
Diseases of snap beans and dry beans	5
Bacterial blights	5
Mosaics	8
Curly top	12
Anthracnose	13
Rust	15
Watery soft rot	17
Powdery mildew	20
Root rots	21
Diseases of snap beans and dry beans—Continued	
Root knot	23
Ashy stem blight	25
Angular leaf spot	26
Web blight	26
Baldhead	27
Sunscald	28
Diseases of lima beans	30
Downy mildew	30
Pod blight	31
Bacterial blight	32
Seed pitting	34
Stem anthracnose	35
Diseases of beans in transit and storage	37

DISEASES of beans are causing severe and widespread damage to this valuable crop every year. In a rainy, cool season they may cost the American farmer $15,000,000. Anyone who grows beans—whether they are to be marketed as a green vegetable, dried, canned, frozen, or used as seed—should give serious effort to preventing losses from disease.

Some of the common diseases of beans result in death of the young seedlings, some result in injury or death of the growing plants, and some result in spots on pods and seeds that make the product unsalable. Most of the serious bean diseases are caused by parasites—chiefly fungi and bacteria, which cannot be seen with the naked eye, and viruses, which cannot be seen even with a compound microscope. Some are caused by such things as extreme heat. Some show that the soil in which beans are being grown contains either too little or too much of one or more minerals.

Fungi and bacteria enter bean plants through natural openings or wounds or even where there are no such openings. They then multiply within the plant tissues and cause spotting of leaves and pods, wilting of tops, or rotting of roots or other plant parts. Frequently they kill the plants. In cool, wet soils, fungi commonly cause decay of planted bean seed.

A fungus produces a mass of threadlike growths, called mycelium. The mycelium produces specialized branches or fruiting bodies that yield spores. The spores serve the purpose of seed. When they have matured they can germinate wherever moisture is present. Fungus spores are scattered by wind, rain, insects, and farm animals. They can be carried from field to field in soil clinging to farm implements or to the farmer's shoes.

Disease-producing bacteria are one-celled organisms that increase by dividing. Once they have entered a bean plant, they increase very

[1] Original version of bulletin was written by L. L. Harter and W. J. Zaumeyer.

rapidly within it and may infect all its parts. A fluid called bacterial ooze flows out onto leaf, stem, and pod surfaces of the infected plant and gradually dries. This fluid contains millions of bacteria. Bacteria can be carried from plant to plant by rain, by insects, by irrigation and drainage water, or on the hands and clothing of field workers.

Some kinds of disease fungi and bacteria are carried from one bean generation to the next in the seed.

Plant viruses, although not so well understood as fungi or bacteria, are known to be spread from one bean plant to another very easily. They are carried chiefly by aphids, or plant lice, and other insects. Some are carried in the seed.

Different kinds of fungi and bacteria affecting beans have different needs as to temperature, rainfall, soil moisture, and other features of environment. For example, the bean disease known as curly top, the virus of which is spread only by the beet leafhopper (frequently called white fly in some parts of the West), is serious only where climate favors this insect. Since beans are grown in all regions of the United States, under many different kinds of environmental conditions, the importance of any one bean disease varies widely among different localities. Losses from any one disease vary from year to year, also, according to seasonal weather conditions. In seasons of heavy rainfall and high humidity, for example, greater losses result from the bacterial blights, anthracnose, and rust than in dry years; and in seasons when cool weather and high soil moisture prevail, heavy losses must be expected from root rot.

This bulletin briefly outlines the known effective methods for preventing and controlling bean diseases, describes the various diseases and their causes, and makes definite recommendations for dealing with each disease.

Soil fumigants and other chemicals recommended here as means of controlling bean diseases are poisonous to man and animals when taken internally. Some of them cause a rash if they even come into contact with the human skin. Anyone using these chemicals should be very careful to keep them away from his mouth, eyes, and nostrils. If he is going to treat a large quantity of seed with a chemical in dust form he should put on a respirator or dust mask to avoid inhaling any of the chemical. If he is going to apply a large quantity of chemical in solution he should put on oiled leather gloves and a rubber or oilcloth apron. In pouring out unused solution, care should be taken to see that it does not stand in puddles but soaks into the ground. After chemicals are used the vessels that have contained them should be cleaned thoroughly and the hands and clothing of the user should be washed. Poisonous chemicals should never be stored within reach of children.

If a bean grower finds a disease he cannot identify with the help of descriptions and photographs given here, or needs advice on the control of bean diseases beyond what is given here, it is suggested that he consult the local county agricultural agent or a specialist of the State agricultural college.

CONTROL PRACTICES

USING RESISTANT VARIETIES

The most satisfactory way of controlling certain bean diseases is to grow varieties that are resistant to them. A grower should never plant a bean variety that is known to be susceptible to a disease when he can plant a suitable variety known to be resistant. In the discussions of individual diseases that follow, the known desirable resistant varieties of beans are listed.

USING DISEASE-FREE SEED

Because some of the principal diseases of beans are carried by the seed, growers should make every effort to use seed from disease-free crops. Some of the seed-borne diseases cannot develop in localities that have low rainfall and high temperatures during the growing season; therefore seed produced in the Mountain and Pacific States is less likely to carry disease than seed grown east of the Rockies, and should be preferred for planting in any region.

A grower who saves bean seed from his own crop in order to avoid the expense of buying seed usually is making a mistake. This practice makes planting only a little less expensive, and may lead to heavy loss in the value of the crop. Seed should be bought from reputable firms, and should not be selected on the basis of price alone. Producing high-quality, disease-free seed is a costly process. It requires special knowledge of the characteristics of different varieties and special practices for keeping the stock pure and true to type and maintaining or improving quality. Seed companies employ experts for this work. Therefore they are better equipped than private bean growers to produce high-grade, noninfected seed, and the growers should be willing to pay a higher-than-average price for such seed.

CROP ROTATION

The germs of most bean diseases can live in the soil for several years, on dead plant material, ready to infect a new bean crop. If beans are grown year after year where such germs are present in the soil, the germs multiply. We cannot definitely tell yet how long a crop rotation should be used to control some bean diseases, for we do not know what lengths of time are needed to starve out some of the disease organisms in different climates and different soil types. It seems possible that in the Mountain States the bacteria causing common and halo blights and bacterial wilt can overwinter in the soil for 2 years; so a 3-year rotation is recommended for western beanfields where these diseases have appeared. The bean rust fungus, so far as is known, lives only 1 year; the watery soft rot fungus sometimes lives as long as 10 years. In some of the following discussions of individual diseases, recommendations are made as to what crops should be rotated with beans where these diseases are present and how long the rotation should be.

FIELD SANITATION

The lives of some disease germs in the soil are shortened if dead plant material decays rapidly. For this reason, refuse remaining in a field after threshing and straw returned to a field should be plowed under as soon after harvest as possible. Old bean stacks near fields that are to be planted to beans should in general be eliminated by using the straw for feeding or bedding livestock, as this tends to reduce the danger of spread of disease organisms.

Some of the fungi, bacteria, and viruses causing bean diseases attack weeds growing in beanfields or nearby. The fungus causing watery soft rot, for example, is very likely to attack ragweed. When a bean crop has been seriously affected by disease and the field is abandoned, any weeds in or near the field should be plowed under as soon as possible, in order to prevent infection of future crops. Certain viruses affecting beans are carried to beans by insects from other crops. For example, the virus causing yellow bean mosaic can be carried to beans from sweetclover, crimson clover, and gladiolus. Beans should not be planted near any crop known to harbor a virus affecting beans, and any known plant carrier of such a virus growing wild along ditchbanks or fence rows near a beanfield should be eradicated.

SEED TREATMENT

Disinfecting bean seed with chemicals has failed as a method of controlling seed-borne diseases. It destroys the germs on the surface but cannot reach those beneath the seed coat without injuring the seed itself. Dusting the seed with certain chemicals has proved beneficial in preventing seed decay and increasing the vigor of the plants produced. Where beans are to be planted in cool, wet soils, good results

FIGURE 1.—Bacterial blight on leaves of snap beans. *A*, Halo blight as it develops under cool conditions. Each lesion is a spot of dead tissue surrounded by a greenish-yellow area. *B*, Common bacterial blight. The lesions have turned brown and have merged to form several extensive dead areas.

in preventing seed decay are usually obtained by dusting the seed with Spergon at the rate of 1½ ounces per bushel or with Arasan at a rate of 1½ to 2 ounces per bushel.

DISEASES OF SNAP BEANS AND DRY BEANS [2]

BACTERIAL BLIGHTS

Bacterial blights are among the most important diseases of beans wherever rain falls frequently during the growing season. In certain parts of the United States, some blight damage to bean crops takes place every year. Only in some parts of the Mountain and Pacific States are bean crops fairly safe from losses caused by this group of diseases.

Bean diseases known in the United States as bacterial blight include common blight, halo blight, bacterial wilt, and fuscous blight. Each of these is caused by a different kind of bacteria, but each produces very similar symptoms on bean plants. Fuscous blight, unlike the others, has come to attention only recently. It is becoming common in New York and has appeared in the Mountain States.

Description

Bacterial blights show up strikingly on bean leaves. First, small water-soaked spots appear on the under side of the leaf. (These spots, and dead areas within living tissues in general, are called lesions.) As the spots develop, dried bacterial ooze usually can be seen in the center of each. In halo blight, under cool conditions, a greenish-yellow circle forms around each spot (fig. 1, *A*). Blight lesions may turn brown, and different spots may merge, forming an extensive brown, dead area (fig. 1, *B*). In time this process may cause every leaf on the plant to die and fall.

On stems of young bean seedlings, also, blight lesions sometimes appear as small water-soaked spots. Such a spot gradually grows larger and then turns a reddish color. On older plants, long reddish lesions may appear extending lengthwise along the stem. When pods are beginning to form on blight-infected bean plants, a kind of lesion known as stem girdle or joint rot often appears. This starts as a small water-soaked area usually at one of the lower nodes of the plant. Growing larger, the lesion encircles the stem, usually when the pods are half mature. Later it turns an amber color. Often the increasing weight of the top causes the stem to break at the diseased node.

Bacterial blight damage to bean pods is often severe. Very small water-soaked spots appear and grow larger. Usually each spot contains a series of irregular bands of different colors, one surrounding another, and the tissue around each spot is reddish brown or brick red. Finally the spots become dry and sunken, often with a covering of dried bacterial ooze. Bacterial blight on pods of snap beans is illustrated in figure 2 and on the cover of this bulletin.

The bacteria may infect the hinge, or upper suture, of the pod,

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[2] In this section, except where lima beans are mentioned, the word "beans" signifies snap and dry varieties only. Some of the diseases discussed here are, however, serious as diseases of lima beans.

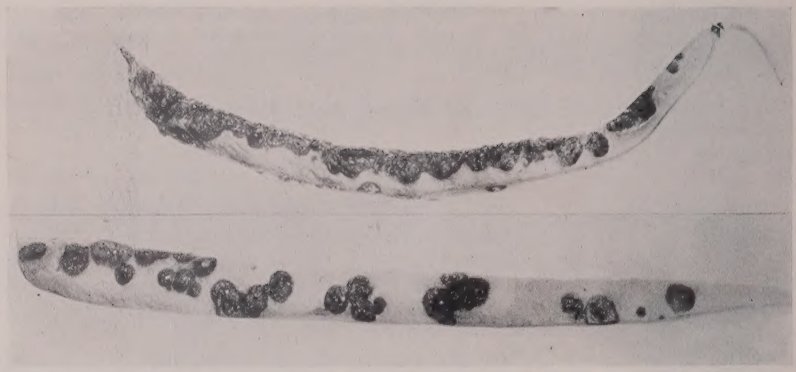

FIGURE 2.—Pods severely spotted by bacterial blight. Bacterial ooze has hardened at the centers of lesions.

causing discoloration of this part and water soaking of tissue on both sides of it. Through the hinge they may attack the seed. If pods become infected while still young, the bacteria may discolor the hilum (the part of a seed at which it is attached to the pod) and surrounding tissue, giving the tissue a varnished appearance. On light-colored bean seed these effects are conspicuous, but on dark-colored seed they are likely to be overlooked. Infected seed may appear to be entirely healthy. Infection of young pods may have much more destructive results, causing the seed to rot completely or be reduced to empty, shriveled seed coats (fig. 3).

When seed badly affected by bacterial blight are planted, the seedlings produced are likely to be stunted and may not push through the ground at all. Some of the seedlings may grow to fairly good size; but usually, if such a seedling is examined closely, a lesion will be found at the node where the cotyledons ("seed leaves") were attached.

Halo blight, if it occurs under cool conditions, can be identified by the halo-like greenish-yellow areas, roughly circular, that surround the leaf lesions it produces (fig. 1, *A*). In early stages of development, leaves of bean plants infected with halo blight have a characteristic yellow color. Young leaves of plants infected with common blight, on the other hand, rapidly turn brown, looking as if they had been burned (fig. 1, *B*).

The ooze of common blight is yellow; that of halo blight is light cream or silvery.

Bacterial wilt does not commonly produce the conspicuous water-soaked areas on stem, leaf, and pod that are characteristic of common blight and halo blight. Pod infection with bacterial wilt often cannot be detected until the pod is opened. The infected seed are yellow and usually shrunken.

Fuscous blight resembles common blight so closely that positive identification can hardly be made without laboratory tests.

Cause

The organisms causing bacterial blights of snap and dry beans are as follows: Common blight, *Xanthomonas phaseoli* (E. F. Sm.) Dows.; halo blight, *Pseudomonas phaseolicola* (Burk.) Dows.; bac-

terial wilt, *Corynebacterium flaccumfaciens* (Hedges) Dows.; fuscous blight, *X. phaseoli* var. *fuscans* (Burk.) Starr and Burk.

Blight bacteria commonly enter bean plants through the stomata (breathing pores) of leaves, stems, and pods. Rain and damp weather favor spread and development of blight bacteria, especially those of common, fuscous, and halo blights. Dampness causes greater quantities of ooze to form and greater quantities of bacteria to adhere to insects and other carriers. Also, the splashing of rain spreads the bacteria from plant to plant. Heavy dews, driving rains, and hailstorms are particularly favorable. When a beanfield is wet, these bacteria can spread rapidly from a few infected plants to other plants throughout the field. Warm temperatures favor common blight, fuscous blight, and bacterial wilt; cool temperatures favor halo blight.

In addition to being carried by bean seed, blight bacteria can live over winter on dead plant material in the soil, possibly for 2 years.

Control

To prevent losses from bacterial blight, the bean grower should above all avoid using infected seed. He should use only seed grown in a far-western [3] area where, for reasons of climate, blight epidemics do not occur. A place where blight epidemics occur infrequently is not a good source of bean seed because there is no way of predicting in what years it will be free of epidemics.

Since blight bacteria can live over winter in the soil possibly for 2 years, planting of beans must be discontinued for 2 years on land where a crop has been infected with blight and it is unwise to plant

FIGURE 3.—These bean seed have been shriveled and in some instances killed by common bacterial blight.

[3] In this bulletin, "the far West" refers to the regions lying west of the Great Plains.

beans on the same land for more than 1 year at a time even if infection has not been discovered there. Crops suitable for rotating with snap beans and dry beans in order to avoid blight infection do not include lima beans, soybeans, or cowpeas, because each of these plants is susceptible to one or more kinds of blight.

No commercially grown varieties of snap or dry beans have proved to be highly resistant to common blight. Dry bean types such as Pinto, Great Northern, Red Mexican, and pea beans and some varieties of the semipole and pole types of snap beans are fairly tolerant of halo blight; that is, they may be infected with it and yet develop almost normally. Little is known about resistance of snap and dry beans to bacterial wilt.

To avoid spreading blight from infected to uninfected bean plants, the bean grower should avoid working in his fields when the plants are wet.

MOSAICS

The bean mosaics are a group of diseases bean growers are likely to overlook even in years when these diseases are serious. The virus causing a mosaic disease may infect every plant in a field and reduce yield, quality, and selling price of the product considerably, but it rarely kills a plant and often produces no conspicuous symptoms. In many parts of the United States mosaic diseases spread widely through beanfields in some years. On an average, it is estimated, bean mosaic losses to the American farmer total several millions of dollars per year.

Description

The principal mosaic diseases of beans are (1) common bean mosaic, (2) a variant strain of this disease, and (3) yellow bean mosaic. The first two affect only beans and a few related plants. Under field conditions it is practically impossible to tell these two apart. Yellow mosaic affects many plants in addition to beans.

Common bean mosaic, the most widespread of the three, results in stunting of the plant and mottling and malformation of leaves (fig. 4). Affected leaves usually have irregular-shaped light-yellow and light-green areas of various sizes. This mottling is sometimes the only evidence of the disease. In addition there may be considerable puckering and other alterations in leaf shape. The affected leaves may be narrower and longer than normal leaves, with considerable downward cupping due to unevenness of growth of the leaf tissues. Bean plants infected with the common mosaic virus early in the season are likely to turn a yellowish green, often are dwarfed and spindling, and usually do not produce more than a small crop. Plants attacked late in the season may produce an almost normal crop.

On beans of certain varieties the variant strain produces symptoms that cannot be distinguished from those of common mosaic. Yellow bean mosaic has distinctly different symptoms. In this disease the contrast between the yellow and the green areas of the affected leaves is much more intense (fig. 5), and the plants become decidedly dwarfed and bunchy.

Both common and yellow bean mosaic sometimes seriously deform pods (fig. 6) and cause their surfaces to become rough and shiny.

Cause

The bean mosaics are caused by viruses, which are carried most commonly by aphids, or plant lice. The aphids spread the viruses by feeding on infected and then on healthy plants. Yellow bean mosaic is spread to beans from sweetclover, crimson clover, red clover, and gladiolus—and, of course, from other beans. The virus of any of the principal mosaic diseases of beans cannot be spread from infected to healthy beans by cultivation, roguing, or picking, although the viruses of several less common bean mosaic diseases can be spread by these operations. The viruses of common bean mosaic and its variant usually spread through all parts of a plant, even entering some seed. Seed thus infected may look normal, but they carry the virus and produce diseased plants. Some plants produced from such seed fail to mature. Others, slightly infected, mature but produce diseased seed. The virus of yellow bean mosaic usually spreads through all plant parts other than the seed, but it never enters the seed.

FIGURE 4.—The mottling, puckering, and malformation of these bean leaves were caused by common bean mosaic, a virus disease.

Symptoms of mosaic disease usually develop about 10 days after infection. Under cool conditions, however, the infected plants may never show any noticeable symptoms.

FIGURE 5.—Yellow mosaic is identified by the striking contrast between yellow and green areas of the affected leaves.

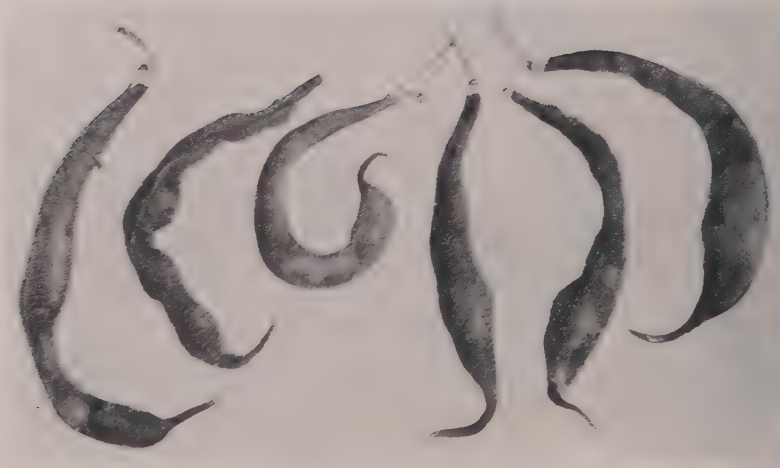

FIGURE 6.—Pods severely deformed by yellow bean mosaic.

Control

The one satisfactory method of control for common bean mosaic and its variant is to use suitable mosaic-resistant bean varieties. This method does not apply to yellow bean mosaic, for no bean variety resistant to the virus producing this disease has yet been developed. Roguing diseased plants from the field, although it gives only temporary relief, is sometimes a practical method of controlling common mosaic where no great number of plants are infected, particularly if the crop is being grown for seed. Where yellow bean mosaic is prevalent, fence rows and ditchbanks should be kept free of sweetclover, crimson clover, and red clover. It is wise not to plant beans close to fields of these clovers or of gladiolus.

Here is a list of the mosaic-resistant varieties and strains of snap and dry beans and some of the susceptible varieties and strains among those now popular:[4]

Snap Beans

RESISTANT TO COMMON BEAN MOSAIC AND ITS VARIANT	SUSCEPTIBLE TO COMMON BEAN MOSAIC AND ITS VARIANT
Bush Types—	Bush Types—
Florida Belle, Logan, Puregold, Rival, Idaho Refugee, Medal Refugee, Sensation Refugee Nos. 1066 and 1071, U. S. No. 5 Refugee, Topcrop	Black Valentine, Bountiful, Brittle Wax, Cherokee, Full Measure, Improved Golden Wax, Landreth Stringless Green Pod, Longgreen, Plentiful, Pencil Pod Black Wax, Sure Crop Wax, Tendergreen
Pole Types—	
Blue Lake, Blue Lake Stringless, Golden Gate Wax, Kentucky Wonder, White Kentucky Wonder, U. S. No. 3 Kentucky Wonder, Potomac, Ranger, Rialto	

Dry Beans

RESISTANT TO COMMON BEAN MOSAIC	SUSCEPTIBLE TO COMMON BEAN MOSAIC
Pea bean: Robust, Michelite	Pinto: Idaho, New Mexico Nos. 295 and 641, San Juan, Wyoming, U. S. Nos. 5 and 14
Great Northern: U. I. Nos. 16, 31, 59, and 123, Montana No. 1	Red Kidney, Small White, Pink, Cranberry, Bayo
Red Mexican U. I. Nos. 3 and 34	
Pinto U. I. Nos. 72, 78, and 111	
RESISTANT TO VARIANT STRAIN	**SUSCEPTIBLE TO VARIANT STRAIN**
Great Northern U. I. Nos. 16, 31, 59, and 123	Robust, Michelite, Red Mexican U. I. Nos. 3 and 34

[4] The initials "U. S." before a name signify that the variety or strain was produced by the U. S. Department of Agriculture. The initials "U. I." signify production by the University of Idaho.

CURLY TOP

Curly top, a virus disease of many cultivated and wild plants, sometimes gives serious trouble in beanfields of Utah, Idaho, Washington, Oregon, California, and other western States. In most of these States the disease is not serious on beans every year but almost completely ruins the bean crop in some years when there is a large population of the insect that carries it, the beet leafhopper.

Description

Plants infected in the seedling stage turn yellow and usually die. On plants infected at later stages the leaves pucker and curl downward (fig. 7) and the veins clear. Young leaves on infected plants of some varieties are decidedly dwarfed and have a darker-than-normal green color. Cupping of the leaves sometimes continues until each leaf looks like a small green ball. Often the young leaves cease to develop, then turn yellow and curl downward. Leaves thus affected are thicker than normal and are very brittle, readily breaking off from the main stem. Generally, under these conditions, the plants die before pods develop. Any pods that do develop are decidedly dwarfed.

Plants infected late in the season do not always develop typical symptoms of the disease, and generally grow to maturity. Often, however, the pods they produce are stunted.

Cause

Curly top is caused by a virus, which is spread from plant to plant only by the beet leafhopper. This insect, frequently referred to in some parts of the West as the white fly, is known scientifically as *Circulifer tenellus* (Baker). It overwinters and produces its spring young on various perennial and winter annual weeds and other plants in abandoned and sagebrush areas of the far West. Many of these plants are susceptible to the curly top virus, and the spring brood of leafhoppers may carry the virus from them into cultivated fields of beets, beans, tomatoes, and other crops. Leafhoppers feeding on plants in abandoned and desert areas usually migrate when these plants begin to mature and dry. Symptoms appear on infected bean plants about 10 days to 2 weeks after infection, and a severely infected plant may die within a few weeks after that. The curly top virus is not seed-borne.

The severity of curly top epidemics varies from year to year according to the size of the beet leafhopper population and the percentage of the insects carrying the virus.

Control

The best way to control curly top of snap and dry beans is to grow suitable resistant varieties. Dry bean varieties resistant to both curly top and common mosaic are Red Mexican U. I. Nos. 3 and 34, Great Northern U. I. Nos. 16 and 31, and Pinto U. I. Nos. 72, 78, and 111. Dry beans resistant only to curly top are Pink and Red Mexican. Pioneer, a small white bean that can be used either as a snap or as a dry variety, is resistant to both curly top and common mosaic. Among susceptible varieties of snap beans, some that can be grown without danger of severe loss from curly top in years of medium leafhopper

population are Burpee Stringless Green Pod, Idaho Refugee, and Landreth Stringless Green Pod. Among the varieties most seriously damaged by curly top are Plentiful, Bountiful, and Kentucky Wonder. Since the curly top virus is not seed-borne, bean seed grown where it is prevalent can safely be planted in any part of the country.

FIGURE 7.—Three bean plants of equal age. The one in the center was stunted and deformed by curly top.

ANTHRACNOSE

Bean anthracnose, a disease caused by a seed-borne fungus, occasionally causes losses of snap and dry beans in the Eastern, Midwestern, and Southern States. The anthracnose fungus is favored if the weather during the growing season is moderately cool and is humid or rainy. Infection may occur on any part of the plant above the ground and at almost any stage of growth. In recent years, since use of western-grown bean seed has become widespread, bean anthracnose has been less important.

Description

Bean seed infected with the anthracnose fungus have dark, sunken lesions of various sizes, which may extend through the seed coat into the cotyledons. When mature, the lesions have pinkish masses of spores at their centers. Lesions on the stems are oval sunken cankers, extending up and down the stem. Their principal color ranges from brown to very dark brown, and they have purplish to brick-red borders. The fungus may so weaken bean stems that they are easily broken in cultivation or by a strong wind.

Anthracnose infection of bean leaves generally follows the veins on the under side, causing them to become purplish or reddish. It may have this effect on most of the veins of a leaf or on only a few of them. A severe attack causes angular dead spots to appear on the upper leaf surfaces, giving the leaves a ragged appearance.

It is on the pods, however, that the symptoms of the disease are most conspicuous. Here the lesions begin as very small reddish-brown elongated spots, often numerous. These spots gradually become more or less circular and sink at the center. A border of a rusty to brown color forms around each of them. Mature lesions (fig. 8) may be one-fourth inch or larger in diameter. During moist weather the fungus produces numerous spores, which give the cankers a pinkish color. When the pods are being picked, young lesions are sometimes hard to detect; but under favorable conditions they may develop into conspicuous cankers within a few days.

Cause

Anthracnose is caused by the fungus *Colletotrichum lindemuthianum* (Sacc. and Magn.) Briosi and Cav., which attacks not only beans but some other related plants. Spores produced in lesions on bean pods, stems, and young leaves are scattered by wind and rain to other plant parts and to other plants. They may be carried, also, on the bodies of insects, on the hands of bean pickers, on farming implements, and in various other ways. In some localities there is evidence that wild animals feeding on or running among diseased plants spread the infection. A sticky substance surrounds the spores and causes them to adhere to whatever they touch.

Often the fungus grows entirely through the wall of a pod and enters the seed, where it may remain alive, buried under the seed coats, for months or even for years. When seed thus infected are planted and germinate, the fungus begins to grow and forms lesions on the cotyledons. From these lesions, infection may be carried to the stem, other leaves, and pods.

The anthracnose fungus is very sensitive to changes in temperature and humidity. It develops most abundantly in cool, wet weather and largely disappears under hot, dry conditions.

The fungus may live over from one season to the next on old bean vines in the field or in bean seed. It is not known just how long the spores will survive under field conditions, but apparently they can live at least 2 years.

FIGURE 8.—Pods in an advanced stage of anthracnose infection, with masses of light-colored spores at the centers of lesions.

Control

The most effective control measures for bean anthracnose are (1) using disease-free seed, (2) rotating crops, (3) staying out of the field when the plants are wet, and (4) spraying.

Disease-free seed can be obtained with certainty only from regions where anthracnose does not occur, that is, from the Mountain and Pacific States.

Where danger of anthracnose infection exists, it is advisable not to plant snap or dry beans on the same ground oftener than once every 3 or 4 years.

Because spores of the anthracnose fungus adhere to clothing and machinery, it is not advisable to cultivate or pick beans, or to enter beanfields for any other purpose, at a time when the plants are wet.

Within recent years these fungicide treatments have been reported to have proved effective in reducing anthracnose infection:

Fungicide:	*Pounds per 100 gallons of water*
Phygon-XL	1
Fermate or Karbam-black	2
Dithane Z-78 or Parzate	1½ to 2
Zerlate, Zimate, or Karbam-white	2

Anyone using these preparations should be careful to follow the instructions given by the manufacturers.

See statement on page 2 regarding precautions to be taken in using chemical fungicides.

RUST

Bean rust causes substantial losses in parts of the far West and the South. In some years it is one of the most important diseases of dry beans in the irrigated areas of Colorado, Wyoming, and Montana. It has caused losses also on coastal lands of southern California, Oregon, Washington, Florida, and other States. The fungus causing this disease is greatly influenced by weather conditions. It is favored by damp, rainy weather with cool nights. For this reason, in some localities bean rust often appears only in the latter part of the growing season or in the fall. However, occasional summer epidemics of the disease in bean-growing districts of the Mountain States have been severe enough to destroy the entire crop.

Description

Bean rust is chiefly a disease of the leaves (fig. 9), but occurs also on stems and pods. Its first symptom is small white spots or flecks on the under sides of leaves. Within a few days these break open into rust-colored lesions of the type resembling pimples, called pustules, about the size of pinheads. These lesions appear on both the upper and the lower leaf surfaces. As many as 2,000 have been counted on a single leaf. A week or so after the pustules appear, the entire leaf begins to turn yellow. Later it turns brown, shrivels, dries up, and falls from the plant. Often a seriously infected beanfield looks as if it had been scorched.

Cause

Bean rust is caused by the fungus *Uromyces phaseoli typica* Arthur. This fungus reproduces by means of spores and has several stages.

Usually the grower notices only the summer stage, which shows up as reddish-brown pustules containing thousands of reddish-brown spores. These spores readily come off on the hands and clothing of anyone touching the plant. In this way, and also through wind action, they spread from plant to plant and from field to field. Toward fall the rust produces spores of another kind, black ones that are

FIGURE 9.—Rust is sometimes one of the principal diseases of dry beans in certain Rocky Mountain areas. Rust pustules, seen here on both upper and lower surfaces of leaves, may cause defoliation of bean plants.

very hardy and live over winter, principally on old bean straw. A few of the summer spores, also, live over winter. The fungus is not known to live more than 1 year. It is not seed-borne.

Rust gets a start in beanfields principally through two mistakes on the part of bean growers: (1) Planting beans on land where beans were infected with rust the preceding year. This is particularly risky where beans have been harvested with a combine and the infested straw has been left in the field and not plowed under until late the following spring. Rust spores on the straw germinate in early spring and infect the new crop. (2) Growing beans close to stacks of old bean straw heavily infested with rust. From such stacks rust spores are blown to nearby beanfields, where they infect the small plants.

Control

Methods for control of bean rust include dusting with sulfur, rotating crops, eliminating stacks of old bean straw, and planting disease-resistant bean varieties. At present, the most effective of these methods is dusting with sulfur.

If finely ground sulfur (about 325 mesh or finer) is dusted on beans in suitable quantity fairly early in the season, before any rust spots become noticeable, this treatment effectively protects the crop from rust infection. The sulfur destroys rust pustules present at that time, stopping spread of spores from such spots and thus preventing formation of other spots. If dusting is done after the rust infection has spread widely in a field, it must be repeated and even then does not give such complete control. About 20 to 25 pounds of sulfur per acre should be used in each dusting.

If beans are planted on land that produced a crop heavily infected with rust the preceding year, or close to stacks of old bean straw infested with rust, the new crop will become infected earlier in the season and more severely than it would have under other conditions. Infested bean straw should be used for feeding or bedding livestock.

All the common dry bean varieties are susceptible to rust. For farmers who grow Pinto beans, the Department of Agriculture has developed two rust-resistant Pinto varieties, called No. 5 and No. 14. None of the bush snap bean varieties are resistant to rust, but most are highly tolerant of it. Some of the common pole snap beans, such as Blue Lake, McCaslan, and Kentucky Wonder, are very susceptible to rust. Tolerant pole varieties include White Kentucky Wonder, U. S. No. 3 Kentucky Wonder, Potomac, and Rialto.

WATERY SOFT ROT

Watery soft rot, or white mold, has recently become important as a disease of beans in several parts of the United States. In certain years it has caused heavy losses in beanfields of southern Florida. It is serious also in the bean-growing sections of Wyoming, Idaho, and Montana, and on snap beans in western Oregon.

High humidities and fairly cool temperatures are necessary for development of the fungus that causes watery soft rot. In irrigated beanfields heavy vine growth causes the plants to stay moist for rather long periods, and this permits the fungus to become active. The fungus develops best between 60° and 70° F.

Description

Watery soft rot of beans affects the stems, leaves, and pods (fig. 10). First small soft, watery spots appear. Under cool, moist conditions these spots enlarge rapidly. Often they girdle main stems and branches, causing them to wilt and die. An infected pod soon turns

FIGURE 10.—Pods in an advanced stage of watery soft rot. The black bodies seen within the masses of mold are sclerotia, by means of which the fungus causing the disease reproduces.

into a soft, watery mass. Often a sticky brown liquid exudes from the pods and stands on them in small drops. After the watery stage the affected tissues dry out, becoming light and punky.

Within a day or two after infection, dense masses of white mold grow out over the infected spots. These white masses have the appearance of small patches of snow. Soon they turn light gray or brown, and small hard, black bodies called sclerotia, looking like bits of charcoal, appear within them. Mold on infected bean pods in shipping baskets causes the pods to nest, or stick together.

Bean seeds attacked by the fungus causing watery soft rot become dull and chalky in appearance and are lighter in weight than normal seeds.

Cause

Watery soft rot is caused by the fungus *Sclerotinia sclerotiorum* (Lib.) DBy. The black sclerotia formed in the mold fall to the ground. When moisture conditions and temperature are favorable for fungus growth, strands of white mold may then grow out of these bodies and infect bean plants directly. Infection in this way is fairly common, particularly when the plants are young. If conditions are not favorable when the sclerotia fall to the ground they can remain in a resting stage for a considerable period—sometimes, apparently, as long as 10 years.

Infection takes place also by means of spores. From the sclerotia grow very small bodies resembling mushrooms, each of which may produce many thousands of spores. These spores are thrown forcibly into the air. If blown to nearby bean plants, they germinate on any dead plant parts—such as old blossoms, stems, or leaves—and proceed to the growing tissues. Soon new masses of mold appear, and in these more sclerotia are formed. Since each sclerotium is capable of producing a large number of the spore-bearing bodies and each of these bodies may produce many thousands of spores, even a few sclerotia in one field can soon cause widespread infection in several adjoining fields.

The sclerotia are capable of living over from one year to another in the soil and thus of perpetuating and increasing the infection.

Just how watery soft rot can get a start in a locality is not definitely known. Possibly spores are blown through the air for considerable distances. Apparently, infection can be carried by the slightly infected seed that survive in some infected bean pods. It is possible for a few of the sclerotia to become mixed in seed lots and thus pass from one locality to another unnoticed. In the seed-producing areas of the far West the use of combines, feeding of straw to sheep, and later use of manure sometimes spread the sclerotia. Another likely way of spreading the fungus to new fields and farms is the practice of feeding cull beans to sheep.

Control

No bean varieties are known to be resistant to the fungus causing watery soft rot, and no spray or dust materials have been found to control the disease. There are, however, several practices that can usually be depended on to reduce the losses caused by the disease.

A high percentage of the sclerotia can be destroyed by flooding infected fields for periods of 3 weeks or more. In preparation for flooding, all plants—including weeds and grasses—should be cut down

so that they will be covered by the floodwater. Because high temperatures hasten decay, the best season for flooding is summer.

Broadcast applications of calcium cyanamide at the rate of 1,000 pounds per acre have given very good results on some soils. The cyanamide should be cut in with a disk harrow to a depth of about 3 inches, and beans should not be planted on the treated area until about 60 days later. Cyanamide injures germinating seed; therefore it must be broken down through natural chemical action in the soil before the treated area becomes safe for planting.

For precautions to be taken in handling calcium cyanamide, which is a deadly poison, see page 2.

Since high humidity favors watery soft rot, any method of bean culture that will reduce the amount of moisture in the surface soil and air around the plants will aid in controlling the disease. A field where the disease is found should not be irrigated more often than necessary. Wider spacing of rows and reduced rates of seeding, which prevent the vines from meeting early in the season and allow better air circulation, are two other methods for reducing the moisture around the plants and thus checking development of the rot fungus.

Many weeds, such as ragweed and milkweed, are known to be susceptible to watery soft rot. If these are allowed to grow along roads, ditches, and canals close to beanfields, they may become sources of infection. Beanfields that have been abandoned because of infection should be kept free of weeds.

Infested bean straw and cull beans contaminated with sclerotia should not be fed to animals if the manure is to be used on land where beans may soon be planted. Screenings from bean cleaning mills, which may contain large quantities of sclerotia, should be burned.

When possible, infested beanfields should be planted for 2 years or more to crops that are not susceptible to watery soft rot. Such crops include small grains, corn, and hay. While this is not likely to eliminate the trouble entirely, it will reduce losses on beans to a considerable extent. Likewise, beans should not follow other crops, or weeds, that are known to have been seriously infected with the fungus causing watery soft rot.

POWDERY MILDEW

Powdery mildew is more important in the Southern States and along the Pacific coast than elsewhere. Usually it causes the most damage to crops maturing late in the fall and crops produced in the extreme South during the winter.

Description

In powdery mildew, a white substance resembling powder is produced on all above-ground parts of the plant (fig. 11). Leaves turn yellow and, in extreme cases, fall off. Often pods are malformed, small, and poorly filled and fall off before any seed mature. Pods and stems often turn a purplish color.

Cause

Powdery mildew is caused by the fungus *Erysiphe polygoni* DC. The spores of this fungus, produced in great numbers on leaves, pods, and stems, are easily dislodged and carried from one plant to an-

FIGURE 11.—Here powdery mildew, a fungus disease that develops very rapidly, has reached a rather advanced stage. The bean crop could still be saved by dusting with finely ground sulfur. If not dusted, the plants will lose all their leaves.

other either by wind or in some other way. Powdery mildew develops so rapidly that an entire bean crop may be badly damaged within a few days.

Control

Powdery mildew of beans can be held in check by dusting the infected crop once or twice with finely ground sulfur. The first application should be made as soon as any evidence of the disease is seen. The second should follow within a week or 10 days.

A variety of snap bean that resists one form of this disease may be susceptible to another. Snap beans only slightly susceptible to powdery mildew are Florida Belle, Logan, Ranger, Idaho Refugee, Sensation Refugee Nos. 1066 and 1071, Rival, Topcrop, Blue Lake, Blue Lake Stringless, Kentucky Wonder, and White Kentucky Wonder. Some of the very susceptible varieties are Black Valentine, Bountiful, Burpee Stringless Green Pod, Giant Stringless Green Pod, Plentiful, Tendergreen, and Sure Crop Wax.

ROOT ROTS

Parasites that cause root rot of beans exist wherever beans are grown. They are more numerous and do more damage to the crop in the South than in any other region of this country. Within recent years some of them have become a serious problem in parts of the West. Most of these parasites live in the soil, on decomposed vegetable matter, and can attack bean plants whenever soil conditions and weather become unfavorable for best growth of the plants.

Most of the parasites causing root rot of beans form lesions of various sizes on the stem below the soil level (fig. 12) and on the fibrous rootlets. These lesions may be gray, brown, black, or even bright red. Frequently the parasites cause the tips of the fibrous roots to decay. Some of them cause stunting and general yellowing of the plant.

When root rot of beans is caused by *Fusarium* fungi, usually a reddish discoloration appears on the taproot. This discoloration may extend to the soil line. The plants are stunted, and the leaves may turn yellow. Sometimes the main root and the lower part of the stem become pithy and dry. Usually the rootlets that develop from the taproot are killed. In that case a cluster of rootlets develops above the lesion, a little below the soil line. These rootlets keep the plant alive, and if weather conditions are favorable an almost normal crop may be produced.

In the type of this disease known as rhizoctonia root rot, bean seed may rot in the ground before or during germination, seedlings may be twisted and stunted, and reddish-brown cankers may form on the roots and on the stems, particularly below or at the soil line. Often these cankers girdle the stem. Young seedlings thus affected damp off, that is, they rot at the soil line. Older plants may remain erect, but they are stunted and their leaves turn yellow.

FIGURE 12.—Wherever beans are grown, fungi are present in the soil that can cause their roots to rot. Dry root rot, illustrated here, is one of several different root rots of beans. The one effective method of control known is to give beans the best possible conditions for vigorous growth.

In the types of root rot known as pythium wilt and southern wilt, the plant wilts suddenly and dies. Pythium wilt usually occurs only on the stem, at the soil line. The affected tissue becomes soft and slimy and can easily be separated from the central cylinder of the stem. Sometimes the stem is girdled. Usually the infection does not extend much below the surface of the soil.

In southern wilt, bean roots and stems rot and become dry and papery. A white fungus growth develops on the stem at the soil line and spreads into the soil around the plant. If the plant is pulled out of the soil a collar of soil and fungus mycelium clings to it.

Cause

The most common of the fungi that cause root rot of beans are *Rhizoctonia solani* Kuehn, *Fusarium solani* f. *phaseoli* (Burk.) Snyder and Hansen, *Pythium butleri* Subr., and *Sclerotium rolfsii* Sacc. The *Fusarium* fungus causes dry root rot, and the *Sclerotium* fungus causes southern wilt. All these four except *F. solani* f. *phaseoli* cause root rot of other crops. All can live for long periods in soil where no cultivated crop is being grown. The *Rhizoctonia* fungus very commonly attacks potatoes. It is normal for root-rot fungi to be present in practically all soils.

Root-rot organisms, with the exception of *Sclerotium rolfsii*, are favored by cool weather and high soil moisture content.

Control

No effective method is known for controlling the various root-rot fungi. No bean varieties are resistant to any of them. However, these fungi seem to thrive least well under conditions that are ideal for bean crops. The *Rhizoctonia* fungus, in particular, is not aggressive under conditions that favor production of strong, vigorously growing bean plants; where the soil is warm and the seed are planted shallowly, it does little harm. Therefore, everything that the grower can do to make conditions favorable for his beans tends to make them unfavorable for these parasites. A rotation of at least 4 or 5 years is recommended. The cropping system should include cereals (corn, oats, and others), clover, and alfalfa, plants to which the fungi causing root rot of beans rarely or never do any lasting damage.

ROOT KNOT

Root knot, a bean disease found chiefly on the light sandy soils of the South and on similar soils in California, prevents a bean plant from developing normally and may even kill it.

Description

In root knot, fleshy, irregular-shaped galls are produced on bean roots (fig. 13). Root-knot galls may sometimes be confused with the nodules that normally develop on the roots of snap and dry beans, lima beans, and other legumes. The galls can easily be identified, however, because they are enlargements of the roots themselves, whereas the nodules are attached rather loosely to the sides of roots. The galls are usually larger than the nodules and are more irregular in shape.

The bacteria that cause formation of the nodules change nitrogen of the air into forms that are beneficial to the plant. Therefore plants bearing root nodules generally grow well and look healthy. Plants with root knot, on the other hand, are usually stunted, yellow, and sickly looking.

FIGURE 13.—Root knot. Each gall on these bean roots was caused by one or more eelworms, or nematodes, that entered the root and began to feed on it. Root knot prevents a plant from growing normally and may kill it.

Cause

Root knot is caused by a parasitic eelworm, or nematode, called *Heterodera marioni* (Cornu) Goodey, so small that it can hardly be seen with the naked eye. The females of this eelworm—or nema, as it is commonly called—enter the small roots and cause them to form the galls characteristic of the disease. If one of these galls is broken open, often a pearl-white body smaller than a pinhead can be seen within it. This is the worm that caused the gall. The galls seriously interfere with movement of food material from the roots to other parts of the plant. The eelworms migrate very slowly in the soil, probably not covering more than 1 to 2 yards in a year. They overwinter in the soil.

Control

The root knot nemas are parasitic on many cultivated plants and on many weeds. This fact makes it very hard to control them. Plants immune to them include beggarweed, crotalaria, oats, and rye. Where soil has become infested with the nemas, growing any of these plants for 3 years makes it possible to grow beans again successfully. One resistant snap bean variety is the pole bean Alabama No. 1.

The more vigorous a bean plant is, the better chance it has to escape severe damage by nematodes. In many instances a bean crop can be saved from such damage by fertilizing the soil and providing the plants with plenty of moisture. Clean cultivation should be practiced in nematode-infested beanfields to keep down weeds on which the nemas could feed.

If beans must be planted on land infested with root knot nematodes, it is advisable to fumigate the soil with some such preparation as dichloropropene-dichloropropane (commonly known as Shell DD or Dowfume N), ethylene dibromide, or methyl bromide. Such treatment often improves germination and growth and increases yields. Anyone using one of these fumigants should be careful to follow the instructions given by the manufacturer.

See statement on page 2 regarding precautions to be taken in using fumigants.

So far as possible, bean growers should guard against the carrying of root knot nematodes from one field to another in tubers, bulbs, or roots of living plants, on implements, in drainage water, by roaming farm animals, or in any other way.

ASHY STEM BLIGHT

Ashy stem blight, a bean disease now common in the South, elsewhere along the Atlantic seaboard, and in California, sometimes causes very large losses. This disease is more serious in seasons of rather heavy rainfall and high temperatures. In dry seasons it often disappears.

Description

Infection with the fungus causing ashy stem blight begins on the bean stem at or below soil level. It extends down into the roots and also up into the branches. The lesions on young plants are somewhat sunken and have a reddish-brown color. As a lesion enlarges it turns ash-gray at the center. Numerous black fruiting bodies, about the size of a pinpoint, appear at the center, standing out in sharp contrast against the gray background. Infection usually takes place on a young plant, and an infected plant usually dies before it produces seed. If infection is delayed until the primary leaves are fully developed, the fungus makes slower progress. On an older plant, the lesions are only a little sunken, if at all. Frequently the disease is more pronounced on one side of the plant, causing the primary leaf on that side to droop and die and any remaining leaves to turn yellow.

Cause

Ashy stem blight is caused by the fungus *Macrophomina phaseoli* (Maubl.) Ashby. Many spores are produced in the black fruiting bodies of the stem lesions. The fungus is seed-borne. Apparently, also, it lives over from one season to the next on plants left in the field.

Control

No control for ashy stem blight has been developed. Since the fungus causing the disease is seed-borne, no beans of an infected crop

should be used as seed. A 2- or 3-year rotation with crops other than snap or dry beans, lima beans, and sweetpotatoes is advisable.

ANGULAR LEAF SPOT

A bean disease called angular leaf spot occurs occasionally in the Eastern and Southern States. It reduces the vitality of the plants and lowers yields, but usually it does not cause serious losses.

Description

The small spots described by the name "angular leaf spot" are brown at first, but when the fungus causing the disease fruits they become more or less gray. Sometimes they are numerous enough to cause leaf fall. The spots on the pods are usually small, but are sometimes large and conspicuous and may run together across the whole width of the pod.

Cause

Angular leaf spot is caused by the fungus *Isariopsis griseola* Sacc. Spores produced on the under sides of leaves, in the lesions caused by this fungus are scattered by wind and rain, and in this way new infections are caused.

Control

Angular leaf spot is rarely severe or common enough to require control. Infected plants have been sprayed with a 4–4–50 bordeaux mixture, but without well-defined results.

WEB BLIGHT

Web blight has caused serious losses of beans in Florida over a period of several years, and has been reported on beans in other Southern States.

Description

The web blight fungus produces small round water-soaked spots on bean leaves and mycelial growth resembling spider webs on bean stems, pods, and leaves. Many small brown sclerotia are imbedded in the mycelium. The spots on leaves are much lighter in color than the healthy tissue and look as if they had been scalded. They take on a tan color, and dark borders form around them. On young pods the spots are light tan and irregular in shape. On mature pods they are dark brown and sunken. In some cases the lesions look very much like those of anthracnose. Sometimes they run together over an entire pod. In the later stages of the disease, if the weather is favorable, the mycelium spreads to all parts of the plant and binds leaves, petioles, flowers, and pods together.

Cause

Web blight is caused by the fungus *Rhizoctonia microsclerotia* Matz, which is parasitic not only on beans but on tomatoes, beets, eggplants, cucumbers, carrots, and other vegetables. Under favorable conditions the small, light sclerotia of this fungus may be produced in large numbers. They are readily detached from the diseased plants and

may be scattered by wind and rain, by bean pickers, on farm implements, and in other ways.

Control

To reduce losses from web blight the bean grower should avoid planting beans in fields where the disease has recently occurred, especially during rainy periods. He should rotate beans with crops immune to the disease, such as tobacco, corn, and grasses. To prevent accumulation of sclerotia in the soil he should destroy diseased plants as soon as possible after harvest. Where the disease has appeared, spraying with a 3–3–50 bordeaux mixture is recommended.

For precautions to be taken in handling bordeaux mixture, see page 2.

BALDHEAD

Description

When a crop of bean seedlings has just emerged from the ground, the grower often finds that many of them look like those in figure 14. These seedlings have no growing tips. The stem above the cotyledons is only a bare stump. Sometimes this stump grows till it extends an inch or more above the cotyledons. Occasionally the plant dies without making much more growth; usually, however, new shoots develop in the axils of the cotyledons and produce a few flowers and pods. The plant always remains small, and usually it is smothered and crowded out by more vigorous neighboring plants. This abnormality is known as baldhead.

Cause

Baldhead results from mechanical injury to seed or from attack on seed by insects, bacteria, or fungi. Possibly the most common cause is improper threshing, which may damage as much as 20 or 30 percent of a crop of some bean varieties. Frequently threshing damage leaves no visible mark on the surface of the seed. The drier the seed and the greater the speed of the threshing-machine cylinders, the more severely beans are likely to be damaged in threshing. Injury to bean seed may result, also, from improper handling in milling, cleaning, storing, or shipping, particularly if the beans do not contain much moisture. When cup elevators in warehouses are emptied, for example, the contents of the cups are thrown with considerable force, and when beans are delivered to storage bins they frequently roll down a series of slides, sometimes 15 feet long, from one side of the bin to the other. At the end of each slide, the beans strike the wall and may receive a severe impact. After beans are bagged, they may be injured by being thrown or dropped onto a hard surface.

Control

To avoid losses from baldhead, bean growers should refuse to accept seed of which a high percentage is cracked. To avoid damage to bean seed, threshing-machine cylinders should not be operated at high speed and the iron teeth of the cylinders and concaves should be covered with rubber shields or else replaced with teeth of some substance not so hard as iron. Other measures for preventing internal injury of seed that might result in baldhead are improving ware-

FIGURE 14.—Seedlings without normal growing tips are the best that can be expected to develop from damaged seed. Baldhead, as this abnormality is called, commonly results from cracking of seed in a rapidly operated threshing machine. The plants never grow to normal size and are usually smothered out.

house equipment to prevent dropping seed too far and handling seed more carefully after it is bagged.

SUNSCALD

When beans have almost reached maturity, sunscald lesions (fig. 15) are likely to appear on any parts directly exposed to the sun. The fresh lesions are tiny brown or reddish spots, which show up most

conspicuously on the pods. There they develop into short streaks extending diagonally between the sutures. In early stages the lesions look so much like those of bacterial blight that many of them cannot be identified without a microscope. Later they can be identified without much difficulty, because nothing resembling bacterial ooze is present in sunscald.

The spots or streaks gradually grow larger and sometimes become slightly sunken. A single lesion may extend over most of the exposed part of a pod. Spotting may finally appear on the shaded side of a pod, but there it is never so serious as on the surface exposed to the sun. Sometimes brownish-red streaks are seen on shaded stems and petioles.

FIGURE 15.—Brown or reddish lesions may appear on bean pods as a result of long-continued direct exposure to sunlight. These lesions, called sunscald, are sometimes confused with those of bacterial blight.

Sunscald of beans causes no substantial loss. Occasionally, seed in badly spotted pods become slightly discolored, like those in pods affected by bacterial blight. The seed discoloration is often hard to detect, particularly on seed that are naturally dark. It does not prevent production of normal, viable seed.

No practical method of controlling sunscald is known.

DISEASES OF LIMA BEANS [5]

DOWNY MILDEW

Description

Downy mildew may cause heavy damage to lima bean crops during any season favorable for development of the causal fungus. The fungus producing this disease is favored by wet weather with cool nights, heavy dews, and fairly warm days. It is spread by wind, rain, and pickers, and probably also by insects and other means. The disease is most common along the Atlantic seaboard.

Downy mildew of lima beans can be recognized by the white, cottony growth that forms in large patches on the pods (fig. 16). Patches of this white growth on the pods are separated from surrounding healthy

FIGURE 16.—Downy mildew, a fungus disease of lima beans, causes heavy losses in wet seasons. The outstanding symptom is a white growth that appears on pods and also on young leaves, shoots, and flowers.

[5] Two of the diseases discussed only in this section, seed pitting and stem anthracnose, occur also on snap and dry beans.

tissue by purplish borders. Frequently the downy mildew fungus attacks not only pods but young leaves, shoots, and flower parts. Irregular-shaped purplish discolorations often appear on the infected leaves, especially near the veins, without much visible mycelium. Under conditions ideal for development of the fungus, the leaves are killed and the pods shrivel, wilt, and slowly die.

Cause

Downy mildew is caused by the fungus *Phytophthora phaseoli* Thax., which attacks lima beans only. The fungus penetrates seed and lives in them throughout the winter. It also lives over winter on dead vines and pods in the field. Both the seed and the dead plant material are sources of infection of the new crop.

Control

Growers of lima beans should carefully avoid using seed from a crop infected with the fungus that causes downy mildew. The best practice is to use seed produced in some area in the far West, where downy mildew rarely if ever occurs, and to grow the beans on a 2- or 3-year rotation. Spraying with a 4–4–50 bordeaux mixture prevents infection but does not effectively check an established infection. Bordeaux mixture and other copper sprays have been reported to do some injury to lima beans, particularly the Henderson bush variety. The new organic fungicides have not given satisfactory control. The fact that the disease does not occur regularly every year makes it hard to decide when to apply a fungicide.

For precautions to be taken in handling bordeaux mixture and other copper sprays, see page 2.

POD BLIGHT

Pod blight of lima beans has been reported from most of the States along the Atlantic seaboard and from Ohio and West Virginia, and it probably occurs elsewhere. During seasons favorable to it, the pod blight fungus causes considerable damage to the commercial crop.

Description

The first symptom of pod blight is brown patches of irregular shape on the leaves. Often these develop to diameters of one-fourth to three-fourths inch. During the latter part of the growing season the fungus spreads to the pods, where it causes pale, somewhat watery-looking spots. These spots slowly enlarge and gradually darken (fig. 17). Within the blight spots on pods and leaves appear greenish-gray pustules about the size of a pinpoint, arranged roughly in circles. When the pustules break through the surface of a leaf or pod they turn dark brown, sometimes nearly black. Such pustules occasionally appear on the stem of the living plant.

Cause

Pod blight is caused by the fungus *Diaporthe phaseolorum* (Cke. and Ell.) Sacc. This fungus spreads by means of spores produced within pustules on bean pods, leaves, and stems. It lives over winter

FIGURE 17.—Lima bean pods affected by pod blight. Within the large lesions are small dark spots containing spores. The fungus causing the disease spreads by means of spores produced on pods, leaves, and stems.

on dead vines and pods left in the field. It has been found also on the seed.

Control

Little effort has been devoted to control of pod blight. Wherever danger of the infection exists, it is recommended that the plants be sprayed with 4–4–50 bordeaux mixture from the time they are about 2 feet tall. After the crop is harvested, dead vines and pods lying on the ground should be gathered up and burned. Lima beans grown in fields where pod blight has recently occurred should never be used for planting. Planting of lima beans should be done with seed produced in the far West.

For precautions to be taken in handling bordeaux mixture, see page 2.

BACTERIAL BLIGHT

Bacterial blight of lima beans may occur in all parts of the United States where rain falls frequently during the growing season. It does greatest damage along the Atlantic coast and in the South. It occurs

frequently in the Midwest but usually causes almost no reduction in yield there. The term "bacterial blight" applies to three diseases of lima beans—common blight, halo blight, and bacterial spot.

Description

Bacterial blight occurs on the leaves, stems, and pods (figs. 18 and 19). The symptoms of common and halo blights on lima beans closely resemble those on snap and dry beans, and the leaf symptoms of bacterial spot on lima beans resemble those of the two other blights. In general it is very hard to distinguish one of these blights from the others without laboratory tests. In early stages of infection common and halo blights cause water-soaked lesions. In bacterial spot the lesions are not watery and are more regular in outline and usually smaller than in common or halo blight. A band of reddish-brown color near the edge of the leaf lesion is very characteristic of bacterial spot. As the lesions enlarge their centers turn light gray and become dry and papery. The dry, dead centers of lesions often fall away, leaving small holes.

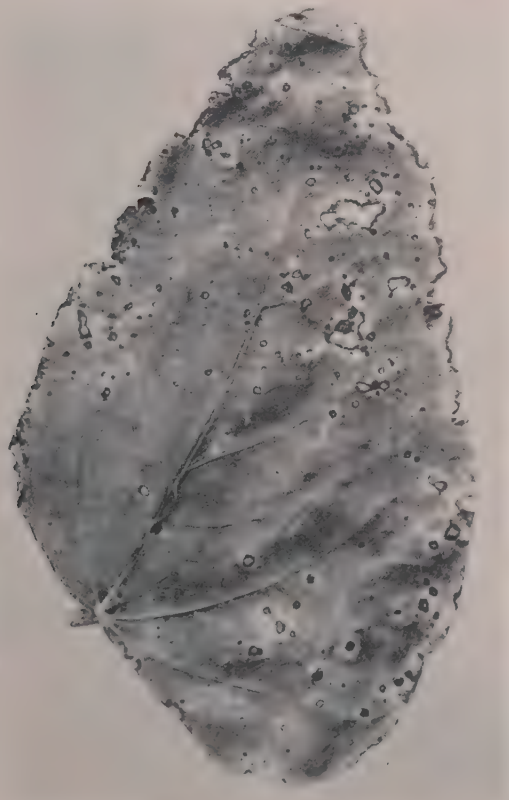

FIGURE 18.—Bacterial spot on lima bean leaf.

Cause

Common blight is caused by *Xanthomonas phaseoli* (E. F. Sm.) Dows.; halo blight, by *Pseudomonas phaseolicola* (Burk.) Dows.; bacterial spot, by *P. syringae* van Hall. These bacteria spread very rapidly from infected plants during heavy rains and hailstorms.

Control

To reduce the danger that a crop of lima beans will be infected with bacterial blight, the seed should be obtained from some area in the far West where blight epidemics do not occur. It is unwise to plant lima beans again on ground where a recent crop has been infected. The rotation should not include snap beans, dry beans, cowpeas, or soybeans, since each of them is susceptible to one or more kinds of blight.

SEED PITTING

Seed pitting, often called yeast spot, spoils many a crop of lima beans in some seasons.

Description

Each of the affected beans has one or more dark, wrinkled spots, irregular in shape and somewhat sunken (fig. 20). Occasionally, the seed coat breaks. In that case, craterlike lesions develop on the cotyledons. Pitting may take place on beans at any stage of growth, but injures them most severely if they are less than half grown. Seed infected at an early stage sometimes fail to develop beyond one-tenth of normal size and often die prematurely. However, they sometimes develop to natural size. No sign of disease appears on the outside of the pod even when the seed are badly pitted.

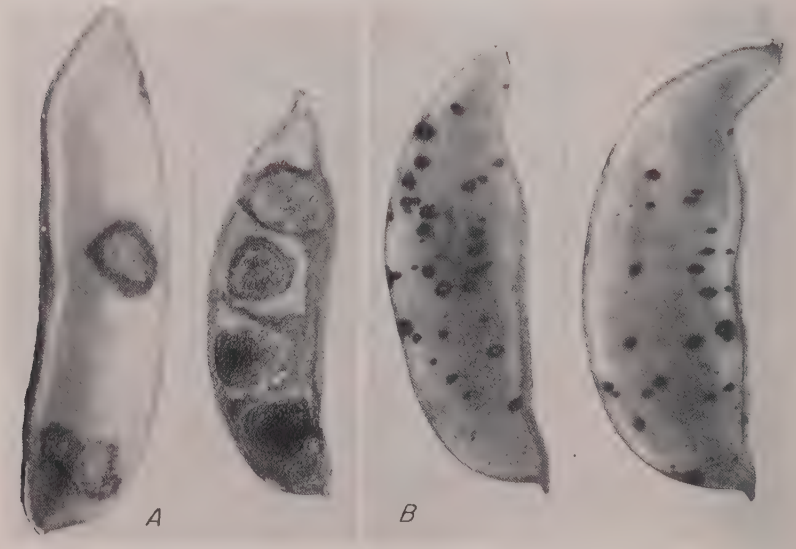

FIGURE 19.—Lima bean pods showing infection (*A*) with common blight and (*B*) with bacterial spot, which causes smaller lesions.

FIGURE 20.—Seed having dark sunken lesions are sometimes found in lima bean pods that look entirely healthy. This seed pitting is caused by insects and possibly by a yeast that enters through punctures made by insects.

Cause

Seed pitting of lima beans is reported to be caused by the yeast *Nematospora phaseoli* Wingard, which enters through punctures made by the southern green stink bug (*Nezara viridula* (L.)) and probably other insects.

In California and Idaho seed pitting very similar in appearance to that attributed to *Nematospora phaseoli*, if not identical with it, results from activity of two lygus bugs (*Lygus hesperus* Kngt. and *L. elisus* Van Duzee) and, possibly, other insects. These bugs poison the bean plant as they feed, with the result that the plant sheds its blossoms or young pods.

Control

No control measures for the yeast spot type of seed pitting have been developed. The large Fordhook lima bean is reported to be less susceptible than the small sieva type.

Five-percent DDT has been found by several workers to be effective in controlling the two lygus bugs mentioned. Field experience in California suggests that growers of lima beans should carefully avoid planting limas next to perennial plants favored by these insects, such as seed beets and alfalfa.

It has not yet been proved that crops treated with DDT can be fed to livestock without danger that milk or meat will become poisonous to humans. For the present, therefore, beans that have been treated with DDT should not be fed to milk animals or to stock that are being finished for slaughter.

STEM ANTHRACNOSE

Stem anthracnose occurs on lima beans (and also on snap beans) chiefly in the Southern and Eastern States. In the South, field losses of 5 to 10 percent of a crop of lima beans from this cause are not uncommon in some years. Further losses have been reported after affected beans reached wholesale markets.

FIGURE 21.—Stem anthracnose of lima beans: *A*, Pods in different stages of the disease; *B*, leaf displaying lesions on both blade and petiole.

Description

Stem anthracnose of lima beans affects the stems, leaves, pods, and seed (fig. 21). A brick-red color is produced along the veins on the under side of the leaf and on the young succulent parts of stem and petiole. Irregular, rough, elongated cankers may appear on the stem. On the pod the first signs of infection are small reddish blotches, which may spread over the entire surface. In later stages of the disease the infected areas become light-brown or grayish and numerous black bodies appear on them. Severe infection dwarfs the plant and causes marked yellowing of the leaves. Not uncommonly, the affected foliage droops and the plant dies.

Cause

Stem anthracnose is caused by the fungus *Colletotrichum truncatum* (Schw.) Andrus and W. D. Moore. Characteristics of this fungus are the same as those of *C. lindemuthianum*, already discussed as the cause of anthracnose.

Control

To control stem anthracnose of lima beans, the grower should use noninfected seed and should rotate other crops with the beans. Limited tests have indicated that certain of the new organic fungicides give effective control. However, some of these preparations killed leaves and caused dropping of blossoms. Copper sprays may injure pods and foliage. Growers should consult county agricultural agents or State agricultural colleges as to what compounds have proved most satisfactory under local conditions.

DISEASES OF BEANS IN TRANSIT AND STORAGE

Nearly all the known diseases occurring on beans while they are being shipped or held in storage arise from conditions existing in the field before or during harvest. Under hot, humid conditions anthracnose, watery soft rot, and some other diseases develop appreciably on beans and spread from pod to pod during 4 or 5 days in transit. If bean pods have become infected with root rot fungi while in contact with soil in the field and are shipped or held at market under high temperature and humidity, the rot infection is likely to spread from them. Bacterial blight can advance from stage to stage but, apparently, blight bacteria cannot spread in shipments of beans.

Beans should be picked only when the vines are dry. They should then be carefully graded, and all those showing blemishes and disease spots should be discarded. The filled hampers should be protected from the direct rays of the sun and from dampness. Preferably, the beans should be cooled before shipment and should be shipped in iced cars. If this cannot be done, they should be shipped as quickly as possible in hampers so packed that the beans are exposed to the air

FIGURE 22.—These snap beans, grown in the South, were field graded and shipped to a northern market without refrigeration. In transit, they were ruined by anthracnose.

FIGURE 23.—Southern-grown snap beans, field graded and shipped north without refrigeration, that were made worthless on the way by watery soft rot.

as much as they can be without danger of spilling beans or breaking hampers.

The fact that grading alone cannot prevent complete loss in transit of beans from a crop infected with anthracnose is illustrated in figure 22. In preparing these beans for shipment the graders threw out all the pods on which they saw any sign of infection. A few days in transit from South to North permitted hidden infection to spread throughout the hamper. In such a case every hamper is sure to include a few infected pods, and unless the shipment is refrigerated the infection is sure to spread rapidly in transit. Before the beans shown in figure 23 were shipped, likewise, the graders threw out all the pods on which they could see any sign of infection with the fungus causing watery soft rot, which was known to be present in the crop. Again, because the shipment was not refrigerated, infection that had escaped the notice of the graders destroyed the value of the beans in transit.

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